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Report to the Chairman, Committee on  
Armed Services, U.S. Senate

January 1994

# STRATEGIC BOMBER

## Issues Relating to the B-1B's Availability and Ability to Perform Conventional Missions



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National Security and  
International Affairs Division

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January 10, 1994

The Honorable Sam Nunn  
Chairman, Committee on Armed Services  
United States Senate

Dear Mr. Chairman:

In response to your request, we have reviewed several issues concerning the B-1B bomber as its operational orientation shifts from nuclear to conventional missions. Our review focused on (1) the operational status of the B-1B fleet and (2) the impact of engine problems and structural cracks found on the aircraft on the availability of B-1Bs.

We briefed your office on the results of our work on September 23, 1993. Following the briefing, in a letter to you dated October 4, 1993, we provided our briefing charts and a brief discussion of the results of our review. As agreed with your office, this report expands and updates the information we presented at the briefing and in the subsequent letter.

## Background

Since the end of the Cold War, the United States has refocused its national security strategy from one aimed at deterring the former Soviet nuclear threat to one that emphasizes conventional war-fighting capabilities. Accordingly, the Air Force has redefined the roles and missions of its strategic bomber force and concluded that the force's conventional capabilities must be enhanced.

The B-1B, which was designed primarily to penetrate the former Soviet Union carrying nuclear weapons, is to be the backbone of this reconfigured bomber force. Air Force plans for modifying and equipping the B-1B with conventional capabilities are outlined in the Bomber Roadmap that was issued in June 1992.<sup>1</sup> This is a significant task because of the different requirements posed by nuclear and conventional missions. For instance, whereas nuclear missions require low-level, high-speed, single-sortie penetration of enemy airspace, conventional missions require repetitive sorties, the ability to forward deploy, and the ability to sustain combat for an extended period. As a result, aircraft and engine availability

<sup>1</sup>We discussed the conventional capabilities currently available in the strategic bomber force and assessed the Air Force's plans, schedules, and costs for equipping strategic bombers with conventional war-fighting capabilities in a February 1993 report, *Strategic Bombers: Adding Conventional Capabilities Will Be Complex, Time-Consuming, and Costly* (GAO/NSIAD-93-45, Feb. 5, 1993).

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are major factors in the B-1B's ability to perform and sustain conventional missions.

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## Results in Brief

According to the Air Force Bomber Roadmap, the Air Force planned to have 60 of the 95 aircraft in the B-1B fleet capable of performing combat missions during conventional conflicts. However, as of September 1993, only 40 B-1Bs were capable of performing combat missions. This number is not expected to significantly increase between now and 2004.

While the Air Force requires 29 of its 65 spare B-1B engines to be serviceable at any given time in order to sustain B-1B operations, only 5 were serviceable when we briefed your office in September 1993. Air Force officials recently advised us that the number of serviceable spare engines increased to 28 as of December 21, 1993. Nevertheless, the number of available serviceable spare engines has historically fluctuated from month to month. During the 21-month period between January 1992 and September 1993, the Air Force had an average of about four serviceable spare engines available. Because spare engines will be critical for the B-1B to sustain repetitive sortie rates required in conventional missions, it is important that the Air Force consistently maintain the required 29 serviceable spare engines over an extended period of time.

Section 132 of the National Defense Authorization Act for Fiscal Year 1994 requires the Secretary of the Air Force to develop a plan to test the operational readiness rate of one B-1B bomber wing that could be sustained if that wing was provided the planned complement of base-level spare parts, maintenance equipment, maintenance manpower, and logistics support equipment. The act further directs that the operational readiness rates of one squadron of the test wing be tested at a remote operating location in a manner consistent with Air Force plans for the use of the B-1B in a conventional conflict. We believe that the test required by the act will provide the Congress and the Department of Defense a better basis than has heretofore been available for measuring the deployability of the B-1B aircraft. That, in turn, will provide for more informed decisions on (1) committing funds for upgrading the B-1B bomber and (2) defining the future conventional roles of the B-52 and B-2 aircraft.

Ice damage to the B-1B's engines and the structural cracks found on the aircraft are detriments to achieving increased aircraft availability. Although the Air Force believes icing will generally not cause in-flight engine failure that could prevent the aircraft from completing a



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conventional mission, engine fan blades could be damaged. As the damaged engines are removed for repair, the demand for spare engines will increase. If spare engines are not available, the fleet's sortie rate will decrease and the B-1B's ability to sustain combat will be reduced.

Cracks in the 25-degree shoulder longeron, a main structure located on the top of the aircraft, were discovered in 1991. The Air Force has made three attempts to address the problem. The first two attempts, designed to slow the cracking, were not successful. Tests indicate that the Air Force's third effort, estimated to cost about \$12 million, will solve the problem. However, according to the Air Force, if this third attempt is not successful, a major structural modification will likely be required.

During an inspection of an aircraft in 1992, the Air Force discovered cracks in the horizontal stabilizer. The extent of this problem is being investigated. At this time, a solution and cost to fix this problem have not been determined. The investigation is expected to be completed in April 1994.

These issues are discussed in more detail in appendix I.

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## Scope and Methodology

In performing our review, we interviewed officials and obtained data at the Air Combat Command, Langley Air Force Base, Virginia; Oklahoma City Air Logistics Center, Tinker Air Force Base, Oklahoma; Rockwell International Corporation, Los Angeles, California; and General Electric, Cincinnati, Ohio.

We performed our review from July through December 1993 in accordance with generally accepted government auditing standards. We did not obtain written comments from the Department of Defense on this report. However, we discussed the information in the report with officials from the Office of the Secretary of Defense, Air Force Headquarters, and the Air Combat Command. They generally agreed with the information and provided updated information that has been incorporated as appropriate.

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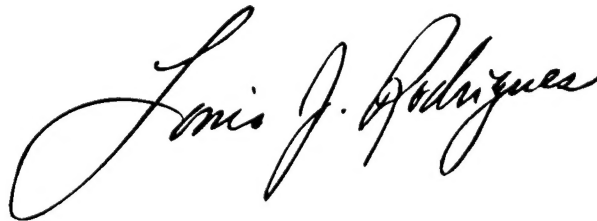
We are sending copies of this report to the appropriate congressional committees; the Secretaries of Defense and the Air Force; and the Director, Office of Management and Budget. We will make copies available to others upon request.



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I can be reached on (202) 512-4841 if you or your staff have any questions concerning this report. The major contributors to this report are listed in appendix II.

Sincerely yours,

A handwritten signature in cursive script, reading "Louis J. Rodrigues". The signature is written in black ink and is positioned above the printed name and title.

Louis J. Rodrigues  
Director, Systems Development  
and Production Issues



# B-1B Bomber's Ability to Perform Conventional Missions

This appendix provides further information on issues related to the B-1B's ability to perform conventional missions.

## Most B-1B Bombers Are Not Mission Capable

The availability of B-1B aircraft is critical to its ability to serve as the backbone of the bomber force in conventional warfare. Availability means the system is in working condition when it is needed and is largely the result of reliability (how often the system breaks down) and maintainability (how long it takes to repair the system).

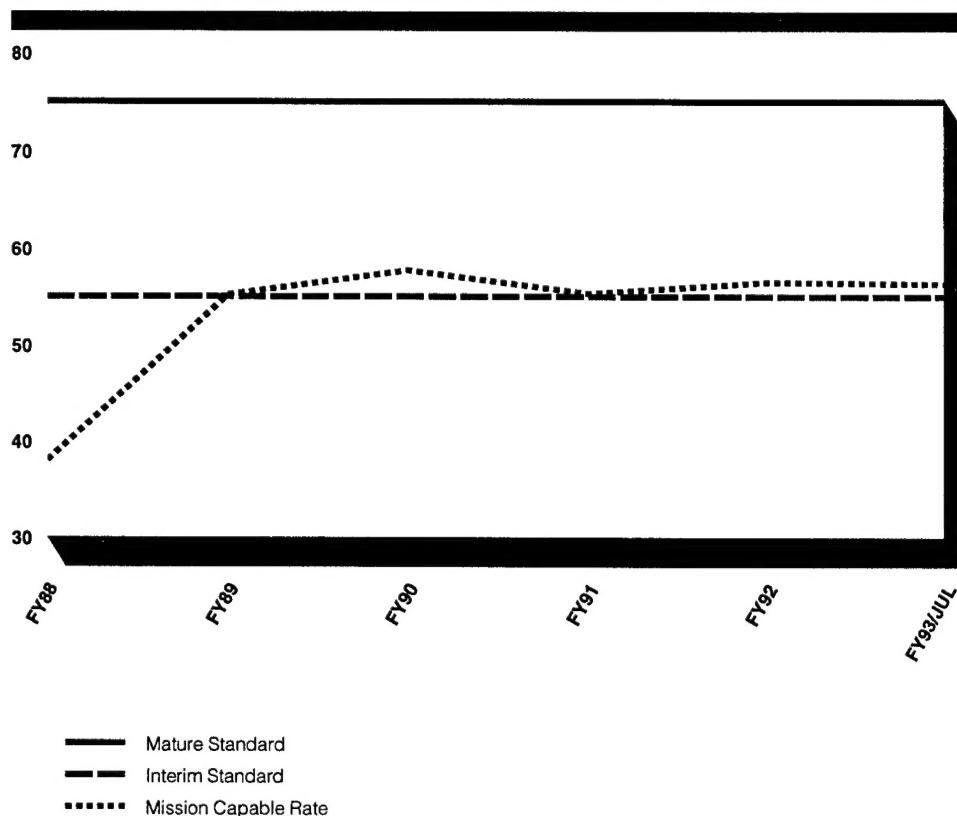
Until recently, the Air Force's peacetime availability standard—referred to as the "mission capable" rate—was 75 percent. That is, at least three-quarters of the B-1Bs at the operating bases were to be available to perform any mission at a given point in time. Although the Air Force goal was to have 80 B-1B aircraft available at operating bases, for the past 3 years on average, about 72 aircraft have been available. The other 23 aircraft were in maintenance, testing, or some other activity that precludes their availability.

The fleet's mission capable rate has never approached 75 percent because of spare parts shortages and maintenance problems. As shown in figure I.1, the fleet's mission capable rate has averaged approximately 56 percent over the past 3 years.



**Appendix I**  
**B-1B Bomber's Ability to Perform**  
**Conventional Missions**

**Figure I.1: Mission Capable Rates of the B-1B Fleet**



In 1992, the Air Force established an interim peacetime mission capable standard of 55 percent. Although the Air Force ultimately expects to raise the mission capable standard back to 75 percent, it does not expect to achieve this rate until sometime after 2004. In June 1993, the Air Force identified a \$300 million funding shortfall which would preclude achieving a 75-percent mission capable rate before the year 2004. Based on proposed funding levels at that time, the Air Force projected a 59-percent mission capable rate by the year 2004.

The Air Force uses a Minimum Essential Subsystem List to determine whether an aircraft is mission capable. The list identifies the minimum essential systems and subsystems that must be operational for an aircraft to accomplish its mission. Discussions with Air Combat Command officials confirmed our calculations that about 40 of the 72 B-1B aircraft available to the operating bases have the minimum essential systems or

subsystems needed to perform combat missions. The remaining aircraft are not mission capable because one or more of the essential systems or subsystems are in need of repair. According to Air Combat Command officials, these aircraft would not be used in combat because to do so would place the crew in jeopardy.

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## Impact of Engine Problems on B-1B Conventional Capabilities

Attention has been focused on upgrades and modifications needed to achieve the Air Force's goal of making the B-1B the backbone of the heavy bomber force for conventional missions. The extent to which problems with the aircraft's engines are resolved will be a major factor in the ability of the fleet to sustain conventional combat operations.

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## Spare Engines Have Been in Short Supply

In addition to the 380 engines that outfit the B-1B fleet (4 engines for each of the 95 aircraft), the Air Force has 65 spare engines. In order to sustain B-1B operations, 29<sup>2</sup> serviceable spare engines are required at any given time, with the other 36 in maintenance. However, the Air Force has had difficulty achieving this requirement, and at times there have not been enough serviceable engines for all 95 aircraft. For example, in November 1992, several aircraft could not fly because they did not have four engines. There were 63 engine "holes" in the fleet, and no serviceable spare engines were available.

This situation has improved somewhat. As of September 1993, each aircraft had 4 engines, but only 5 of the needed 29 serviceable spare engines were available. According to the Air Force officials, the main reason for the lack of serviceable spare engines is premature engine wear-out resulting in maintenance problems and parts shortages. In March 1993, the system program director noted that the aircraft engine was designed with the expectation that it would operate for about 3,000 hours before overhaul. However, certain engine parts, particularly those in the section where combustion takes place, have been wearing out twice as quickly as expected.

As a result of higher wear-out rates and an engine mishap resulting in an in-flight engine failure, in 1992 the Air Force implemented a program, referred to as Lancer 101, to determine appropriate long-term solutions to the engine problems. The program identified a requirement for \$71 million in spare parts to alleviate the early wear-out problem. The program also identified a need for several engine modifications. These modifications are

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<sup>2</sup>At the time we briefed your office in September 1993, the Air Force required 32 spare engines to be serviceable. The Air Force subsequently revised the requirement to 29 serviceable spare engines.

scheduled to begin in fiscal year 1994, with the final phase of the program to be completed in fiscal year 2001.

In December 1993, officials at the Air Force Oklahoma Air Logistics Center told us that the number of serviceable spare engines had increased from the 5 we reported were available in September 1993 to 28 spares. It is noteworthy that the number of serviceable spare engines has historically fluctuated from month to month. In addition, during the 21-month period between January 1992 and September 1993, the Air Force had an average of about four serviceable spare engines available. The number of serviceable spare engines at any given time will be a critical factor in determining the capability of the B-1B to sustain repeated sorties during a conventional conflict.

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### Engine Ice Damage Could Reduce Aircraft Availability

During adverse weather conditions, ice may accumulate on the B-1B aircraft, break off, and enter the engine. If this happens, the ice can damage the engine fan blades. According to the Air Force, ice damage will generally not cause in-flight engine failure and, therefore, will not prevent the aircraft from completing its mission. However, the engines may need to be removed to replace the damaged fan blades. This, in turn, increases the demand for spare engines. If spare engines are not available, as discussed in the previous section, the ability of the fleet to perform conventional missions suffers.

To limit ice damage to the B-1B's engines during peacetime operations, the Air Force imposed a restriction that the engines not be operated when the temperature falls below 47 degrees Fahrenheit and moisture is present. This restriction would be lifted under wartime conditions. In addition, Air Force officials told us that the B-1Bs are sometimes towed to and from the runway to minimize exposure to standing water, and ground observers are used to verify that no ice has built up on the aircraft.

At the Air Force's request, the prime contractor conducted a study to predict the impact of engine ice damage on the B-1B's capability to perform conventional missions. The contractor found that the B-1B would be able to perform conventional missions without significant performance degradation resulting from engine ice damage. However, the study showed that in a worst-case scenario, up to one in every three aircraft could receive engine ice damage while flying combat sorties. According to the prime contractor, the number of sorties would decline dramatically if a sufficient number of spare engines were not available to replace those that



were removed for repair. For example, the study showed that if spare engines were available, 16 deployed aircraft<sup>3</sup> could sustain a total of 13 sorties a day. If spares were not available, the number of sorties the 16 aircraft could sustain would fall to 7 a day because the time required for repair would increase more than fourfold—from 6 hours to 28 hours.

The prime contractor's study included several options to solve the engine icing problem: (1) retrofitting the aircraft with a new anti-icing system, (2) purchasing additional spare engines to ensure an adequate supply, or (3) acquiring additional spare engine blades and repairing the engines as they break down. The Air Force chose the last option. The Air Force plans to stock the additional spare blades where the aircraft are deployed, and damaged engines will be repaired on-site.

The Air Force decided against developing and installing an anti-icing system because of prohibitive costs, long procurement lead times, and various other system-specific problems. Table I.1 summarizes the costs, procurement time, advantages, and disadvantages of each anti-icing system considered.

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<sup>3</sup>According to the prime contractor, at the time of the study it was not known how many or how often the aircraft would be used. Therefore, the study assumed a 16-aircraft wing to support a 30-day war.

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B-1B Bomber's Ability to Perform  
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**Table I.1: Anti-Icing System Options**

| System                                 | Advantage  | Disadvantage  | Phase       | Cost         | Time (Yrs.)  |
|--|--|---|-------------|--------------|--------------|
| Engine Inlet Ice Protection System     | Involves Low technical risk<br><br>Uses existing aircraft interface equipment      | Requires high electrical power  | Development | \$5.5        | 1.50         |
|  |  |   | Retrofit    | 128          | 5.00         |
|  |  |   | Total       | 133.5        | 6.50         |
| Electro-Expulsive De-icing System      | Requires low electrical power  | Involves medium to high technical risk<br>Does not reduce ice to acceptable size                | Development | 20-30        | 3.75         |
|  |  |   | Retrofit    | 130-200      | 5.00         |
|  |  |   | Total       | 150-230      | 8.75         |
| Pneumatic Impulse Ice Protection       | Requires low electrical power<br><br>Reduces ice to acceptable size                | Involves medium to high technical risk  | Development | 20-30        | 3.75         |
|  |  |   | Retrofit    | 130-200      | 5.00         |
|  |  |   | Total       | 150-230      | 8.75         |
| Vortex <sup>a</sup> Dissipation System | Reduces icing when aircraft is on ground<br><br>Reduces hard foreign object damage | Is concept only<br><br>Provides no in-flight ice protection                                     | Development | 2-3          | 1.50         |
|  |  |   | Retrofit    | 58           | 5.00         |
|  |  |   | Total       | 60-61        | 6.50         |
| Engine Bleed Air Anti-icing system     | Involves low technical risk<br><br>Requires electrical power                       | Requires aircraft structural modification   | Development | <sup>b</sup> | <sup>b</sup> |
|  |  |   | Retrofit    | <sup>b</sup> | 5.00         |
|  |  |   | Total       | <sup>b</sup> | <sup>b</sup> |
| Inlet Ice Protection Device            | Works while in-flight and on ground<br><br>Does not require electrical power       | Is heavy--weighs 1,600 pounds<br>Causes 2-4 percent thrust loss<br>Involves high technical risk | Development | 30-50        | 3.75         |
|  |  |   | Retrofit    | 70-80        | 5.00         |
|  |  |   | Total       | 100-115      | 8.75         |

<sup>a</sup>Not a stand-alone system.

<sup>b</sup>Unknown.

The Air Force also cited high costs as the prime reason for rejecting the option of purchasing additional spare engines. The engine production line has been shut down, and while no estimates were made for starting it up again, the Air Force considered the purchase of additional engines to be cost prohibitive.

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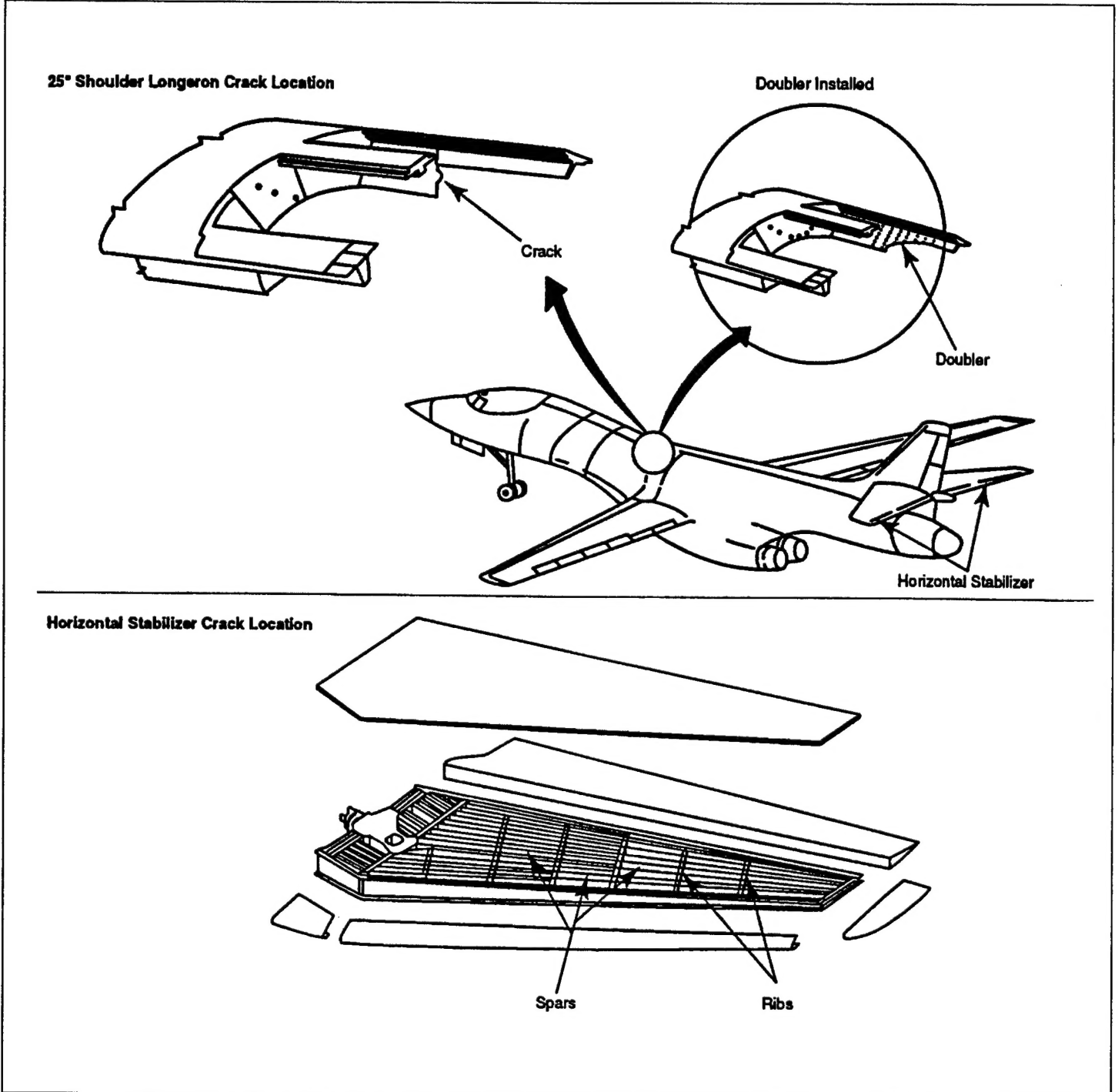
## **Structural Cracking**

Cracking has been discovered in two structures of the B-1B, the longeron and the horizontal stabilizer. The 25-degree shoulder longeron is the main structure located on the top of the aircraft that extends the length of the aircraft. The horizontal stabilizer is on the aircraft's tail section. These structures are shown in figure I.2.



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Figure I.2: Location of Structural Cracks in the B-1B



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## Longeron Cracks

In 1991, cracks began to appear along the longeron of B-1B aircraft. To date, 47 aircraft have developed such cracks. The Air Force has made three attempts to solve this problem. The first two attempts were stop-gap procedures designed to slow down the cracking. The first attempt was a procedure that involved bolting a short aluminum piece, called a doubler, to the longeron. The second attempt involved the use of a longer doubler that was bolted and glued to the longeron. These two procedures did not solve the problem.

The third attempt to fix cracks in the longeron involves a thicker doubler and an improved hot glue bonding procedure. The Air Force expects this procedure will solve the problem. Tests of this fix have been completed. In these tests, the Air Force subjected the repaired longeron to loads that would be experienced on a typical low-level, high-speed mission, plus another 10 percent, for a period of 80 years (or the equivalent of four B-1B lifetimes). No cracking was detected during the tests. The cost of fixing all aircraft in the B-1B fleet with this procedure is estimated to be \$12.3 million. The Air Force plans to fund this fix from the operations and maintenance account.

While testing has been successful, actual aircraft flights will be needed to determine the adequacy of the latest fix to the longeron cracks. If this third attempt does not solve the problem, the Air Force acknowledged that a major structural modification may be required.

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## Horizontal Stabilizer Cracks

In December 1992, during an inspection of a B-1B that had been struck by lightning, it was discovered that aluminum rivets on the horizontal stabilizer's outer layer had become loose, or were missing, causing cracks. The problem is believed to have been caused by vibration. All 95 aircraft have since been inspected, and all were found to have cracks or loose or missing rivets.

The problem has not resulted in a stabilizer failure, and none of the aircraft have been grounded. However, damage extensive enough to suspend flying some of the aircraft has been discovered. As a result, while the Air Force initially planned to examine the internal structure of 10 aircraft—5 with the highest number of flying hours and 5 with the highest number of takeoffs and landings—the Air Force now plans to examine the internal structure of the horizontal stabilizers on all B-1B aircraft. To date, cracks have been found on the ribs and spars of all aircraft that have been inspected. The ribs and spars are the primary

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support structures of the horizontal stabilizer, and any significant cracking would require extensive and costly repairs. The potential repairs and the related cost will not be known until the Air Force completes its inspection of the B-1B fleet, estimated to be April 1994.



# Major Contributors to This Report

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